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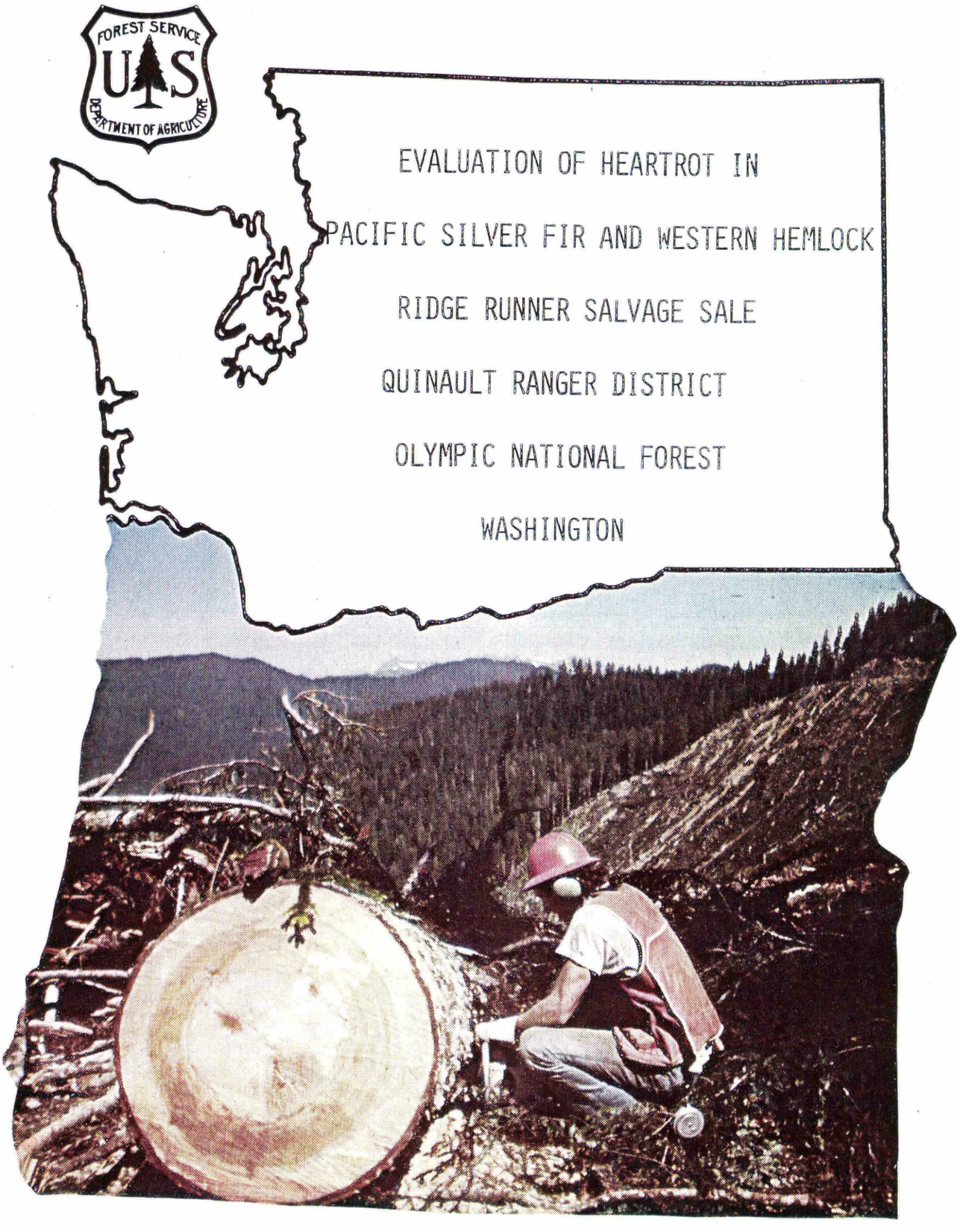

EVALUATION OF HEARTROT IN

PACIFIC SILVER FIR AND WESTERN HEMLOCK

RIDGE RUNNER SALVAGE SALE

QUINAULT RANGER DISTRICT

OLYMPIC NATIONAL FOREST

WASHINGTON

EVALUATION OF HEARTROT IN PACIFIC SILVER FIR AND WESTERN HEMLOCK, RIDGE RUNNER SALVAGE SALE, QUINAULT RANGER DISTRICT, OLYMPIC NATIONAL FOREST, WASHINGTON

by

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Appreciation is extended to Randy Smith for help with sample processing and photography, Frances Lombard for culture identification, and Mel Davis for technical assistance on the Quinault Ranger District.

SUMMARY

Fifty-three felled Pacific silver firs and 8 western hemlocks were examined for external indicators and extent and cause of advanced decay. Total gross volume (board foot) decayed was 10.4% for fir and 52.5% for hemlock. The highest percentage of fir decay was caused by *Hericium abietis* (34.4%), followed by *Echinodontium tinctorium* (20.5%). Hemlock decay was caused primarily by *Armillaria mellea* and *Fomes annosus*. None of the trees decayed by *H. abietis* had external indicators. Conks, wounds, and top damage usually were associated with decay other than that caused by *H. abietis* or brown cubical rot fungi. Heartrot management alternatives are discussed.

INTRODUCTION

During October 1981, Gregory M. Filip, Paul E. Aho, and Kenelm W. Russell, Pathologists from Pacific Northwest Regional Office, Pacific Northwest Forest and Range Experiment Station, and Washington Department of Natural Resources, respectively, visited the Ridge Runner Sale on the Quinault Ranger District (Figure 1) to examine heartrots in Pacific silver fir (*Abies amabilis*) and western hemlock (*Tsuga heterophylla*) that had been blown down in the 1979 Lincoln Day storm (see Evaluation of Pacific Silver Fir Decay, Ridge Runner Sale, Quinault RD, Dec. 7, 1981).

The decay problem was first brought to the attention of pathologists after fir logs from the sale area that were scaled as sound failed to produce expected volumes of sound lumber when cut at the mill. Samples of decayed wood produced cultures of the heartrot fungus, *Hericium abietis*, cause of "long-pocket rot" (Figure 2) as identified by Paul Aho. Extensive rot columns of other decay-causing fungi, *Fomes annosus* and *Armillaria mellea*, were noted also in windthrown trees and stumps in the area.

Information concerning long-pocket rot caused by *H. abietis* in Pacific silver fir appears only in one study conducted in British Columbia (Foster and others 1958). Even within the area examined in that study, the occurrence and damage caused by *H. abietis* in Pacific silver fir was minimal--3.5% of the total infection and 4.8% of the total amount of decay. In an earlier and similar study in British Columbia, no *H. abietis* was found (Bier and others 1948). The

apparently extensive occurrence of *H. abietis* in the Ridge Runner Sale on the Olympic Peninsula was rather puzzling. It was therefore recommended that Forest Pest Management, in consultation with Paul Aho, perform an evaluation to determine the incidence of heartrot, particularly that caused by *H. abietis* in Pacific silver fir, and perhaps develop more accurate cull factors for this and other sales in the area.

OBJECTIVES

Objectives of our evaluation were to:

1. Determine the amount of heartrot, particularly that caused by *H. abietis*, and the relative abundance of this fungus in felled and windthrown Pacific silver fir in the Ridge Runner Sale.

2. Correlate, if possible, the amount of advanced decay, especially that caused by *H. abietis*, with several potential external indicators (wounds, top damage, conks, etc.) on Pacific silver fir.

3. Formulate heartrot management alternatives from analyzed results.

METHODS

In August 1982, one unit (#1) of the 202-acre Ridge Runner Sale was examined (Figure 1). Trees in this unit had been felled and bucked by the sale purchaser and thus were readily accessible for examination. Pacific silver firs and a few western hemlocks were sampled. We selected each tree first at the top of the unit adjacent to the road and, while proceeding downhill, we examined each tree as it was encountered.

Each tree was sampled by first examining the stump for basal wounds and, if any were present, determining size (length x width) and age (by dissection) of wounds. Total age of the tree was determined by stump ring count.

Each log (as cut) of the tree was measured for (1) total length (nearest 0.1 foot); (2) diameter inside bark (d.i.b.) at both ends (nearest inch), and (3) diameter of advanced decay columns at the log ends (nearest inch). External indicators such as conks, wounds, frost cracks, and broken, forked or multiple tops were also recorded and their position on each log drawn to scale on prepared data cards. Size and age of wounds were also recorded. Presence of shake, checks, or cracks was noted for each log. Saprots were not recorded (see Russell 1982 for a method of determining sapwood deterioration in windthrown timber).

Each log was examined for extent of advanced decay by first removing a 1-inch-thick disk from the end of each log to expose a fresh surface (trees had been felled and bucked in 1981, so some weathering of log ends had occurred). Each disk was split several times to expose longitudinal sections, because long-pocket rot is difficult to detect from log ends (Figure 3). Only advanced decay, as determined by ease of penetration of a knife point, was measured. If no advanced decay was observed in freshly-exposed log ends or in dissected disks, no further cutting was done on the log. Also, if small amounts of advanced decay were observed, the depth of the decay into the log was estimated and no

further cutting was done. If moderate to severe amounts of advanced decay were observed, especially if present at both ends, logs were further dissected at 6-foot intervals to determine if columns were continuous. If conks were present, logs were bucked at that point to determine extent (diameter and length) of any associated decay column. If wounds were present, a small wedge of wood was removed from the wound center to determine wound age and decay presence. If extensive advanced decay was present as wounds, the log was bucked to determine extent of the decay column. Extreme care was taken not to buck sound logs or logs with small amounts of decay since the timber had already been purchased.

For all advanced decay columns, the causal organism was identified, if possible, and the type of decay was recorded. For each decay type, a sample of decayed wood was returned to the laboratory for culturing to positively identify decay-causing fungi. In the laboratory, decayed wood samples were split, and 10 wood chips were removed asceptically with a wood gouge from each sample. Each chip was placed in a culture tube containing 2% malt agar with 1 ppm benomyl. Cultures were incubated for at least 6 weeks at room temperatures in the dark, after which all decay fungi were identified to species by the Center for Forest Mycology Research, Madison, WI.

Cubic foot log volumes and decay volumes were calculated by Smalian's formula:

$$V = \frac{b+t}{2} \times L$$

Where V = volume in cubic feet

b = basal area (ft^2) at large end

t = basal area (ft^2) at small end

L = length in feet

basal area = $0.005454\ (\text{diameter})^2$

Board foot log volumes were calculated using Knouf's rule-of-thumb, which closely approaches the Scribner rule (Dilworth 1974):

$$V = \frac{D^2-3D}{10} \times 1/2\ L$$

Where V = log volume in board feet

D = d.i.b. at small end of log in inches

L = log length in feet

Board foot defect volumes, including advanced decay, shake, and checks (but not incipient decay, saprot, crook, sweep, or breakage in felling), were calculated using the squared defect method or standard rule (Dilworth 1974):

$$D = \frac{WxTxL}{15}$$

Where D = deduction in board feet

W = width of defect (plus 1 inch) in inches

T = thickness of defect (plus 1 inch) in inches

L = length of defect in feet

All logs with less than 33-1/3% sound wood remaining after deducting for defect were considered totally decayed (board foot measurements only). Total tree cubic and board foot volumes were calculated as the sum of the volumes of individual logs from that tree. Cull, as used in this evaluation, includes only volumes of shattered or cracked logs not necessarily decayed.

RESULTS AND DISCUSSION

Sixty-one trees (53 Pacific silver fir and 8 western hemlock) were examined for external indicators and extent and type of advanced decay. Total gross volume (board foot) decayed was 10.4% for fir and 52.5% for hemlock (Tables 1 and 2). The highest percentage of fir decay was caused by *Hericium abietis* (34.4%) and *Echinodontium tinctorium* (20.5%), the Indian paint fungus (Table 3). *E. tinctorium* was found to be the most damaging heartrot fungus in one study in British Columbia, causing 64.9% of the decay (Foster and others 1958). In our evaluation, the sample of hemlock with decay was too small to make valid comparisons between incidence of heartrot fungi, but *Armillaria mellea, Fomes annosus, Phellinus pini*, and *E. tinctorium* were identified by decay and cultural characteristics as causing damage (Table 3). The same fungi were found to be important causes of hemlock decay in British Columbia (Foster and others 1958). *F. annosus* and *A. mellea* also were found to cause the most decay in 40- to 120-year-old hemlock stands in Oregon and Washington (Goheen and others 1980).

No correlations between amount of heartrot and DBH or age class were apparent, probably due to the small sample sizes within some DBH classes. Ten fir and one hemlock less than 200 years old appeared to have less decay than older trees. The study in British Columbia (Foster and others 1958), which had a much larger sample of trees, did show a significant positive relationship between amount of heartrot and both increasing DBH and age.

Percent of volume (board foot) that was cull (shattered and broken logs) was only 1.3% for fir and 1.0% for hemlock, because trees that broke after falling had the broken sections bucked out. In many cases, heartrot contributed to tree breakage when trees with decay were felled and also when trees were felled upon a downed tree with heartrot.

Total amount (percent board feet) of decay and cull that we estimated for fir (11.7%) and hemlock (53.5%) differs from the amount of decay and cull for fir (20.9%) and hemlock (42.9%) estimated by the District for the entire Ridge Runner Salvage Sale. This is probably due to the much smaller area and number of trees that we sampled. We also did not deduct for saprot or examine trees or logs that were destroyed totally during felling.

More than half of the trees with decay also had external indicators (Table 1). However, some trees had indicators but no decay. Furthermore, none of the trees with long-pocket rot caused by *H. abietis* had external indicators. Many trees with long-pocket rot had old branch stubs but so did many sound trees.

Table 4 shows that most (61.4%) of the fir decay was not associated with external indicators and can be considered a hidden defect. Although the sample size was small, external indicators associated most consistently with decay were conks (*E. tinctorium* and *F. pini*); broken, forked, or multiple tops on both fir and hemlock; and wounds on hemlock. Four of 14 wounds on fir were not associated with decay, but nearly all of these wounds were very small or young.

Sample size was not large enough to develop multiple regression equations to estimate defect.

Heartrot of grand fir (*A. grandis*) caused by *H. abietis* has a history of being associated with wounds, especially basal wounds (Aho 1977). It is not certain why so much of the *Hericium*-caused decay in the Pacific silver firs we examined was not associated with external indicators. Perhaps the biology of *H. abietis* resembles that of *E. tinctorium* in that infections occur primarily in suppressed advanced regeneration (Herring and Etheridge 1976, Aho 1960 and 1977). Most of the firs that we examined had been growing very slowly throughout their entire lives. *E. tinctorium* infections remain dormant until activated by trunk wounds or the formation of large branch stubs. We observed many large branch stubs on Pacific silver fir, and it may be possible that if dormant infections were present, they may have been activated by the formation of large branch stubs.

HEARTROT MANAGEMENT RECOMMENDATIONS

The following recommendations are suggested for management of heartrot in similar and future stands of Pacific silver fir and western hemlock on the Quinault Ranger District:

1. Continue to use existing cruise estimates for defect in fir and hemlock, paying particular attention to (a) external indicators such as conks, wounds, and top damage and (b) hidden defect particularly caused by *H. abietis* and brown cubical rot fungi.

2. When managing advanced fir or hemlock regeneration, select from adequately stocked groups of crop trees that have (a) good live crown ratios ($\geq$50%), (b) rapid terminal growth and (c) little or no deformities or wounds; trees that are unlikely to be infected with Indian paint fungus or perhaps *H. abietis*.

3. Minimize wounding during stand entries, especially when thinning. Discriminate against already-wounded trees during thinning operations. Incorporate wound prevention guidelines into timber sale contracts.

4. Manage on short rotations, preferably less than 120 years. Decay incidence increases with tree age and becomes especially damaging after 120 years, particularly in western hemlock.

The information and recommendations presented in this report have been specifically formulated for the area we surveyed. Although some of this information may be applied to other areas in Oregon and Washington experiencing similar heartrot problems, these areas may be sufficiently different from the area we surveyed to warrant a separate biological evaluation to formulate management alternatives specific to that area. Forest Pest Management pathologists encourage and are available to perform such evaluations at the request of land managers.

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Table 1--Percentage of 53 Pacific silver firs with decay and external indicators by DBH and age class, Quinault Ranger District, Washington.

DBH Class (in.)	No. of Trees	Percent of Trees with[1] Decay + Indicators	Decay No Indicators	Indicators No decay	No Decay No Indicators	Total Gross Volume[2] CF	BF	Percent Decay Volume CF	BF	Percent Cull[3] CF	BF
15-20	5	0	20	20	60	323.6	1504	0.1	0.9	0.0	0.0
21-25	2	50	0	0	50	237.2	1254	0.6	3.3	0.0	0.0
26-30	11	9	27	18	46	2552.5	15175	3.1	10.2	0.8	0.4
31-35	13	8	23	15	54	4088.9	23771	0.6	2.2	0.5	0.6
36-40	8	62	13	0	25	3896.4	25804	3.0	10.6	1.0	1.2
41-45	8	50	12	25	12	4801.5	31007	7.6	24.7	0.5	0.6
46-50	5	20	20	0	60	3627.4	24033	<0.1	0.2	3.6	3.8
51-55	1	100	0	0	0	986.4	6257	4.9	13.9	0.0	0.0
Total or Average	53	26	19	13	42	20513.9	128805	3.1	10.4	1.2	1.3
AGE CLASS (Yr)											
100-150	1	0	0	0	100	47.8	230	0.0	0.0	0.0	0.0
151-200	9	22	22	22	33	2625.6	16395	1.0	3.4	0.5	0.6
201-250	17	41	6	18	35	5752.5	35576	3.1	10.9	0.6	0.5
251-300	13	15	31	15	39	4238.9	26209	2.7	10.9	0.6	0.7
301-350	2	0	50	0	50	739.2	4434	3.2	17.1	5.5	6.9
351-400	5	40	20	0	40	3578.9	23088	5.0	15.2	1.1	1.3
401-450	2	0	50	0	50	904.3	6018	<0.1	0.4	0.0	0.0
450+	4	25	0	0	75	2626.7	16855	4.2	10.9	3.3	4.0
Total or Average	53	26	19	13	42	20513.9	128805	3.1	10.4	1.2	1.3

1/ Indicators include wounds, conks, and broken, forked, or multiple tops.
2/ CF = cubic foot volume; BF = board foot volume (Scribner).
3/ Cull includes only shattered or cracked logs not necessarily decayed.

Table 2--Percentage of 8 western hemlocks with decay and external indicators by DBH and age class, Quinault Ranger District, Washington.

DBH Class (in.)	No. of Trees	Percent of Trees with[1] Decay + Indicators	Decay No Indicators	Indicators No decay	No Decay No Indicators	Total Gross Volume[2] CF	BF	Percent Decay Volume CF	BF	Percent Cull[3] CF	BF
15-20	1	0	0	0	100	87.8	349	0	0	0	0
21-25	0	-	-	-	-	-	-	-	-	-	-
26-30	0	-	-	-	-	-	-	-	-	-	-
31-35	1	0	0	0	100	322.3	2033	0	0	4.9	5.2
36-40	1	0	0	0	100	507.5	3437	0	0	0	0
41-45	1	0	100	0	0	600.9	4138	2.5	10.4	0	0
46-50	3	100	0	0	0	2309.0	15307	32.6	72.0	1.1	1.3
51-55	1	100	0	0	0	779.9	3801	50.8	100.0	0.0	0.0
Total or Average	8	50	12	0	38	4607.4	29065	25.3	52.5	0.9	1.0
AGE CLASS (Yr)											
100-150	0	-	-	-	-	-	-	-	-	-	-
151-200	1	0	0	0	100	322.3	2033	0	0	0.5	5.2
201-250	2	50	0	0	50	615.3	3576	21.4	69.0	0.0	0.0
251-300	0	-	-	-	-	-	-	-	-	-	-
301-350	0	-	-	-	-	-	-	-	-	-	-
351-400	1	0	100	0	0	600.9	4138	2.5	10.4	0.0	0.0
401-450	4	75	0	0	25	3068.9	19318	33.2	64.0	0.8	1.0
450+	0	0	0	0	0	0.0	0	0.0	0.0	0.0	0.0
Total or Average	8	50	12	0	38	4607.4	29065	25.3	52.5	0.9	1.0

1/ Indicators include wounds, conks, and broken, forked, or multiple tops.
2/ CF =cubic foot volume; BF = board foot volume (Scribner).
3/ Cull includes only shattered or cracked logs not necessarily decayed.

Table 3--Frequency of decay types, with and without external indicators, on Pacific silver fir and western hemlock, Quinault Ranger District, Washington.

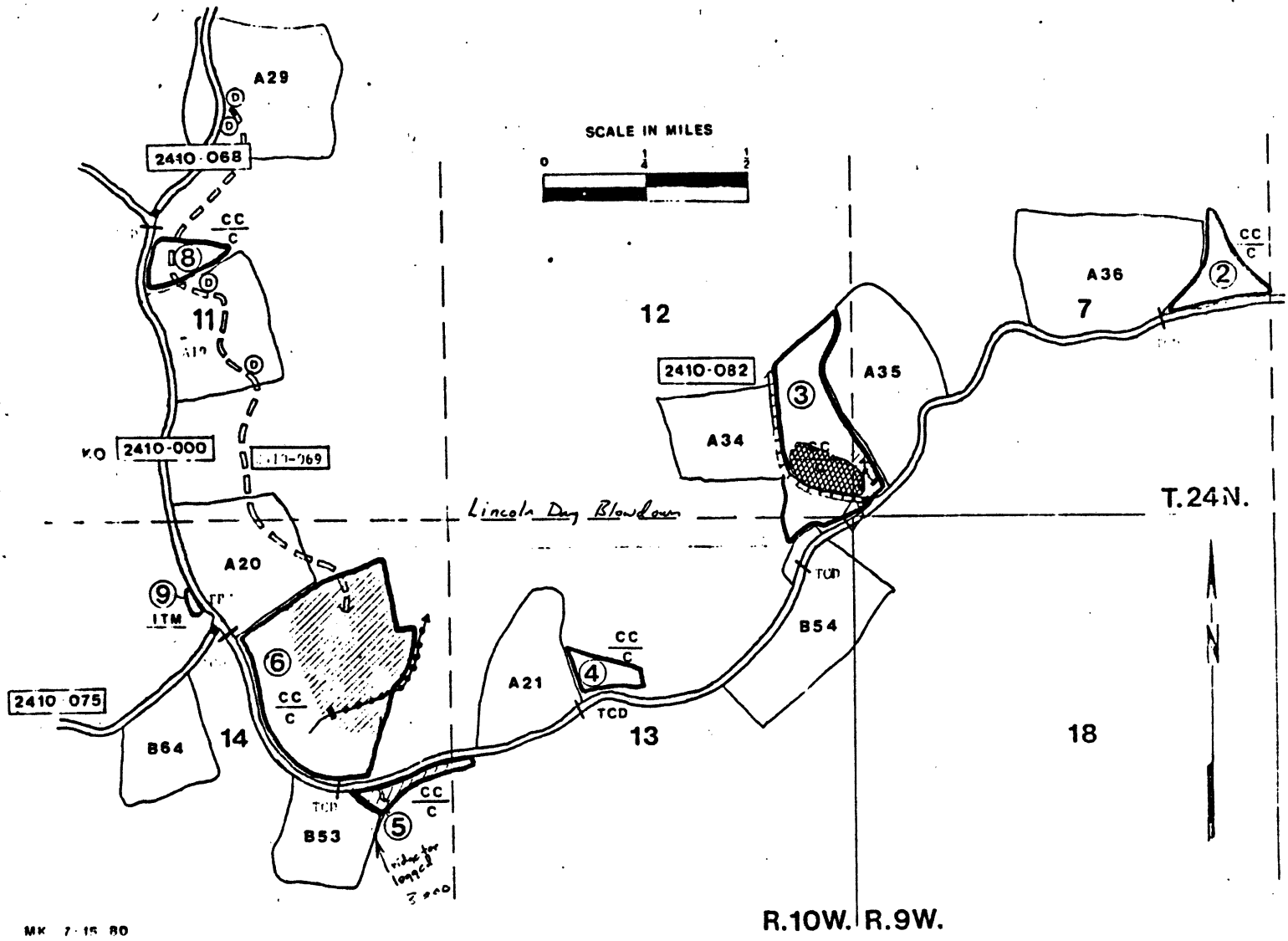
	PACIFIC SILVER FIR				WESTERN HEMLOCK			
Decay Type	No. of Trees[1]	CF[2]	BF[3]	Trees with indicators and decay	No. of trees	CF	BF	Trees with indicators and decay
		- - - - Percent - - - -				- - - - Percent - - - -		
H. abietis	6	34.4	35.5	0	0	-	-	-
E. tinctorium	4	20.5	24.1	50	1	1.3	2.8	0
F. annosus	2	10.5	7.4	100	1	34.0	24.9	100
F. pini	0	-	-	-	1	11.3	16.2	100
A. mellea	0	-	-	-	1	52.7	54.7	100
Brown Cubical Rot[4]	9	29.3	27.7	22	0	-	-	-
Other	9	5.3	5.3	89	1	0.7	1.4	100
Total Decay Volume	30	633.2	13437	-	5	1165.0	15253	-

1/ Some trees had more than one decay type.
2/ CF = percent of cubic foot decay volume.
3/ BF = percent of board foot (Scribner) decay volume.
4/ Includes decay caused by *Laetiporus sulfureus*.

Table 4--Frequency of decay, with and without external indicators, on Pacific silver fir and western hemlock, Quinault Ranger District, Washington.

	PACIFIC SILVER FIR				WESTERN HEMLOCK			
External Indicator	No. of Trees[1]	CF[2]	BF[3]	Trees with indicators but no decay	No. of trees	CF	BF	Trees with indicators but no decay
		- - - - Percent - - - -				- - - - Percent - - - -		
Conks	2	19.1	25.7	0	1	11.3	16.2	0
Wounds	14	16.9	14.5	29	3	87.0	80.1	0
Broken, Forked or Multiple Tops	2	2.7	3.2	0	1	0.5	0.9	0
None	14	61.4	59.5	-	1	1.3	2.8	-
Total Decay Volume	32	633.2	13437		6	1165.0	15253	

1/ Some trees had more than one external indicator.
2/ CF = percent of cubic foot decay volume.
3/ BF = percent of board foot (Scribner) decay volume.



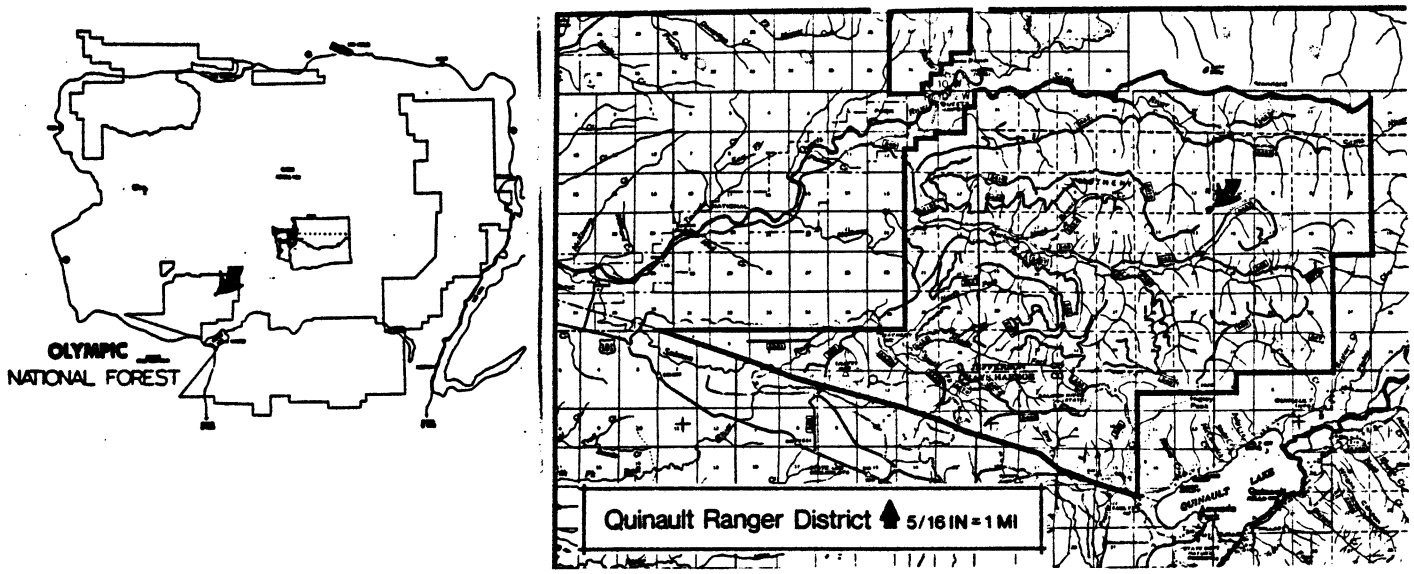


Figure 1--Map depicting the location of the area sampled (cross-hatching) within the Ridge Runner Salvage Sale, Quinault Ranger District.

Figure 2--"Long-pocket rot" caused by *Hericium abietis* in Pacific silver fir heartwood.

Figure 3--Freshly-exposed cross-section of Pacific silver fir log showing "long-pocket rot" caused by *Hericium abietis*. Rot is difficult to detect after log ends dry out.

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